

**UNCLASSIFIED**

---

**AD 401 462**

*Reproduced  
by the*

**DEFENSE DOCUMENTATION CENTER**

**FOR**

**SCIENTIFIC AND TECHNICAL INFORMATION**

**CAMERON STATION, ALEXANDRIA, VIRGINIA**



---

**UNCLASSIFIED**

2

NOTICE: When government or other drawings, specifications or other data are used for any purpose other than in connection with a definitely related government procurement operation, the U. S. Government thereby incurs no responsibility, nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

63 3 2

TM-(L)-721/013/00

CATALOGED BY ASTIA  
AS AD No. 401 462

# TECHNICAL MEMORANDUM

(TM Series)

## ASTIA AVAILABILITY NOTICE

Qualified requesters may obtain  
copies of this report from ASTIA.

This document was produced by SDC in performance of contract AF 19(628)-1648, Space  
Systems Division Program, for Space Systems Division, AFSC.

SCF Computer Program Systems Manual  
General Purpose Satellite Programs  
Compute Satellite Position in Cartesian  
Coordinates (CARTES)

by

J. LaVine

21 January 1963

Approved by

J. D. Marioni

SYSTEM

DEVELOPMENT

CORPORATION

2500 COLORADO AVE.

SANTA MONICA

CALIFORNIA

The views, conclusions or recommendations expressed in this document do not necessarily reflect the official views or policies of agencies of the United States Government.

Permission to quote from this document or to reproduce it, wholly or in part, should be obtained in advance from the System Development Corporation.

Although this document contains no classified information it has not been cleared for open publication by the Department of Defense. Open publication, wholly or in part, is prohibited without the prior approval of the System Development Corporation.



401 462

21 January 1963

10.13.01

TM-(L)-721/013/00

#### SUBROUTINE IDENTIFICATION

- A. Title: Compute Satellite Position in Cartesian Coordinates (CARTES) - Ident. G84, Mod. EA.
- B. Programmed: D. Leder, EI&P, MSVD General Electric Company.
- C. Documented: 15 October 1962, J. LaVine, System Development Corporation.

#### PURPOSE

CARTES computes the position of a satellite in Cartesian Coordinates using given orbital position parameters.

#### USAGE

- A. Calling Sequence.

L	SLJ	4	CARTES
L+1	NOP		
	ZRO	B	L(J)
L+2	NOP		
	ZRO	B	L(R <sub>e</sub> )
L+3	NOP		
	ZRO	B	L(g)
L+4	NOP		
	ZRO	B	L( $\eta_E$ )
L+5	NOP		
	ZRO	B	L(i)
L+6	NOP		
	ZRO	B	L(l <sub>o</sub> )
L+7	NOP		
	ZRO	B	L( $\phi_o$ )
L+8	NOP		
	ZRO	B	L( $\omega$ )
L+9	NOP		
	ZRO	B	L(t <sub>o</sub> )
L+10	NOP		
	ZRO	B	L(a)
L+11	NOP		
	ZRO	B	L(e)

21 January 1963

10.13.02

TM(L) -721/013/00

L+12	NOP		
	ZRO	B	$L(\omega_p)$
L+13	NOP		
	ZRO	B	$L(r)$
L+14	NOP		
	ZRO	B	$L(x)$
L+15	NOP		
	ZRO	B	$L(y)$
L+16	NOP		
	ZRO	B	$L(z)$
L+17	NOP		
	ZRO	B	$L(\dot{x})$
L+18	NOP		
	ZRO	B	$L(\dot{y})$
L+19	NOP		
	ZRO	B	$L(\dot{z})$
L+20	NORMAL RETURN		

The address portion of each lower instruction refers to the location in core of the particular parameter. The B term may be zero, or any legal index register designation.

#### B. Input Parameters

The following parameters must be in the locations specified by the calling sequence. All values are to be in floating point format.

<u>PARAMETER</u>	<u>UNITS</u>	<u>DESCRIPTION</u>
J	N.D.	Coefficient of second spherical harmonic in Earth's gravitation field.
$R_e$	feet	Earth's equatorial radius.
g	feet/sec <sup>2</sup>	Acceleration due to gravity.
$\eta_E$	radians/sec.	Earth's rotation about polar axis.
i	radians	Inclination of orbital plane to equatorial plane.
$l_o$	feet	Semi-latus rectum of mean orbit at time of first ascending node.

21 January 1963

1013.03

TM-(L)-721/013/00

<u>PARAMETER</u>	<u>UNITS</u>	<u>DESCRIPTION</u>
$\phi$	radians	Longitude of first ascending node.
* $\omega$	radians	Total angular travel from first ascending node.
* $t_0$	seconds	Time measured from nominal time of launch.
* $a$	feet	Semi-major axis of mean orbit.
* $e$	N.D.	Eccentricity of mean orbit.
* $\omega_p$	radians	Argument of perigee of mean orbit
* $r$	feet	Geocentric distance

\* These position parameters are obtained from the output of either the KH1 or KH2 subroutine.

#### C. Results

The outputs, which consist of the components of the radius and velocity vectors, are stored as specified by the last six address in the calling sequence. These values are in the form of Cartesian coordinates which represent a geocentric inertial system with the positive Z axis pointing North along the polar axis, the positive X axis along the right ascension of the Greenwich meridian at nominal time of launch, and the Y axis 90° East of the X axis. They are defined as follows:

<u>PARAMETER</u>	<u>UNITS</u>	<u>DESCRIPTION</u>
x, y, z	feet	Coordinates of satellite position (floating point)
$\dot{x}$ , $\dot{y}$ , $\dot{z}$	feet/sec.	Velocity components in the positive x, y, z direction (floating point)

#### RESTRICTIONS

##### A. Accuracy:

The accuracy of this program is affected only by the limitations of floating point arithmetic and the results obtained from the referenced subroutines. This assumes the input orbital elements are within a valid range.

21 January 1963

10.13.04

TM-(L)-721/013/00

B. Environment:

CARTES used the subroutines SIN, COS, SQRT, and SUBERR. The program uses and restores index registers 1 and 2. No Reference Pool items are used.

C. Error Checks:

CARTES makes no validity checks on inputs from the user program or values obtained from other subroutines. The only type of error exit provided is to the SUBERR subroutine upon return from the SIN, COS, or SQRT subroutines.

TIMING

The time required for CARTES to cycle is 3972.2 microseconds plus the time required for the associated subroutines. This figure disregards the possibility of a premature exit caused by an error.

STORAGE REQUIREMENTS

A Space Allocation:

Program	121 cells
Constants	6 cells
Temporary Storage	41 cells
TOTAL	<u>168 cells</u>

REFERENCES

- A. Program 698BJ Milestone XI, V.1, Page IIC-43, Subroutine CARTES Description, General Electric Company, Missile and Space Vehicle Department.
- B. Program 698BJ Command and Control Computer Program Design Specification, Milestone IV, V.1, Page 9067, Subroutine CARTES Design Specification, General Electric Company, Missile and Space Vehicle Department.
- C. TM-(L)-715/011/00, Utility Program Descriptions, Milestone XI, Floating Point Cosine (COS), (AFCPL Number 75011).
- D. TM-(L)-715/012/00, Utility Program Descriptions, Milestone XI, Floating Point Sine (SIN), (AFCPL Number 75045).
- E. IMSD-447578, Page 55.10.21, Systems Manual Subroutine Description for SQRT.

21 January 1963

10.13.05  
(Last Page)

TM-(L)-721/013/00

- F. LMSD-447578, Page 50.10.21, Systems Manual Subroutine Description for SUBERR.
- G. TM(L)-714/023/00, General Purpose Satellite Computer Program Description, Milestone XI, Time to Position by King-Hele (KH1). (AFCPL Number 75685).
- H. TM(L)-714/024/00, General Purpose Satellite Computer Program Description, Milestone XI, Angular Travel to Position by King-Hele, (KH2). (AFCPL Number 75686)
- I. TM-714/025/00, General Purpose Satellite Computer Program Descriptions, Milestone XI, Compute Satellite Position in Cartesian Coordinates (CARTES), 28 December 1962. (AFCPL Catalog Number 75684)



21 January 1963

TM- (L) - 721/013/00

EXTERNAL DISTRIBUTION LIST

<u>AGENCY</u>	<u>AGENCY</u>
Space Systems Division (Contracting Agency) Major C. R. Bond (SSOCD)	PIR-E5 (Aerospace) F. M. Adair R. O. Brandsberg L. H. Garcia G. J. Hansen C. S. Hoff L. J. Kreisberg T. R. Parkin E. E. Retzlaff H. M. Reynolds D. Saadeh R. G. Stephenson V. White
6594th Aerospace Test Wing (Contracting Agency) Lt. Col. A. W. Dill (TWRD) Lt. Col. M. S. McDowell (TWRU) (2)	PIR-E4 (GE-Santa Clara) D. Alexander
PIR-E1 (Lockheed) N. N. Epstein C. H. Finnie H. F. Grover W. E. Moorman 461 Program Office 698BK Program Office	PIR-E4 (GE - Box 8555) J. S. Brainard R. J. Katucki J. D. Selby
PIR-E2 (Philco) J. A. Bean J. A. Isaacs R. Morrison S. M. Stanley	PIR-ER (GE-3198 Chestnut) J. F. Butler H. D. Gilman
PIR-E3 (LFE) D. F. Criley K. B. Williams	PIR-E4 (GE - Bethesda) A. Pacchioli
PIR-E8 (Mellonics) F. Druding	PIR-E4 (GE - Box 8661) J. D. Rogers
PIR-E7 (STL) A. J. Carlson (3)	
PIR-E4 (GE-Sunnyvale) J. Farrentine N. Kirby	

21 January 1963

TM-(L)-721/013/00

DISTRIBUTION LIST (Continued)

<u>NAME</u>	<u>ROOM</u>
Padgett, L. A.	24085
Patin, O. E.	Sunnyvale
Polk, T. W.	24099
Pruett, B. R.	24073
Raybin, M.	14039
Reilly, D.	24085
Remstad, C. L.	27029
Rosenberg, E. J.	14050
Russell, R. S.	14050
Scholz, J. W.	14039
Scott, R. J.	24093
Seacat, C. M.	Sunnyvale
Seiden, H. R.	22091A
Shapiro, R. S.	25026
Skelton, R. H.	24127A
Solomon, J. D.	24053
Speer, N. J.	20079
Stone, E. S.	22116B
Sweeney, M. J.	24057
Taber, W. E.	22053
Tennant, T. C.	27024
Testerman, W. D.	14039
Thompson, J. W.	22077
Thornton, R. L.	14050
Totschek, R. A.	24090A
Vorhaus, A. H.	24076A
Wagner, I. T.	24081
Warshawsky, S. B.	22082
West, G. D.	24117
West, G. P.	24094A
Wilson, G. D.	22101
Winsor, M. E.	24137
Winter, J. E.	24097
Wise, R. C.	24051
Wong, J. P.	Sunnyvale
Zubris, C. J.	24075

31 January 1963

TM- (L) - 721/013/00

DISTRIBUTION LIST

<u>NAME</u>	<u>ROOM</u>	<u>NAME</u>	<u>ROOM</u>
Allfree, D.	22078	Haake, J. W.	24120
Alperin, N. I.	24118A	Harris, E. D.	24083
Armstrong, E.	24089	Henley, D. E.	24058B
		Hill, C. L.	24061
Bernards, R. M.	Sunnyvale	Hillhouse, J.	24049
Biggar, D.	24090B	Holmes, M. A.	22082
Bilek, R. W.	24124	Holzman, H. J.	22096B
Black, H.	14039	Houghton, W. H.	22073
Brenton, L.	22070	Hoyt, R. L.	14039
Burke, B. E.	22076		
Busch, R. E.	24065B	Imel, L.	14039
Carter, J. S.	27032	Kastama, P. T.	24053
Champaign, M. E.	24127B	Kayser, F. M.	25026
Chiodini, C. M.	22078	Keddy, J. R.	25026
Ciaccia, B. G.	24082A	Key, C. D.	24123
Cline, B. J.	24097	Keyes, R. A.	20073
Cogley, J. L.	24135	Kinhead, R. L.	24071
Conger, L.	22079	Kneemeyer, J. A.	24065A
Cooley, P. R.	24083	Knight, R. D.	24110B
Court, T. D.	22073	Kolbo, L. A.	24139
Crum, D. W.	24093	Kostiner, M. N.	14056B
		Kralian, R. P.	14039
Dant, G. B.	22073	Kristensen, K.	Sunnyvale
DeCuir, L. E.	22096A		
Derango, W. C.	24077	LaChapelle, F.	24061
Dexter, G. W.	24128	Laughlin, J. L.	20073
Disse, R. J.	24139	LaVine, J.	20079
Dobbs, G. H.	24094	Little, J. L.	20077
Dobrusky, W. B.	22125	Long, F.	24122
Ellis, R. C.	24081		
Emigh, G. A.	14039	Madrid, G. A.	22049
Ericksen, S. R.	24110A	Mahon, G. A.	20076
		Marioni, J. D.	24076B
Felkins, J.	22070	Martin, W. P.	24089
Foster, G. A.	14039	McKeown, J.	24121
Franks, M. A.	25030	Michaelson, S. A.	14039
Frey, C. R.	24049	Milanese, J. J.	24121
Frieden, H. J.	24071	Munson, J. B.	24048
		Myers, G. L.	14056A
Gardner, S. A.	22053	Nelson, P. A.	24075
Greenwald, I. D.	24058A	Ng, J.	22049
Griffith, E. L.	27029	Ngou, L.	25030

UNCLASSIFIED

System Development Corporation,  
Santa Monica, California  
SCF COMPUTER PROGRAM SYSTEMS MANUAL  
GENERAL PURPOSE SATELLITE PROGRAMS  
COMPUTE SATELLITE POSITION IN CARTESIAN  
COORDINATES (CARTES).  
Scientific rept., TM(L)-721/013/00, by  
J. LaVine. 21 January 1963, 6p.  
(Contract AF 19(628)-1648, Space Systems  
Division Program, for Space Systems  
Division, AFSC)

Unclassified report

DESCRIPTORS: Programming (Computers).  
Satellite Networks.

UNCLASSIFIED

---

States that CARTES computes the position  
of a satellite in Cartesian Coordinates  
using given orbital position parameters.  
Also states that the accuracy of this  
program is affected only by the limitations  
of floating point arithmetic and the  
results obtained from the referenced  
subroutines.

UNCLASSIFIED

UNCLASSIFIED